INNOVATION IN SWEDISH COMPANIES

THE EFFECT OF PRIVATE EQUITY OWNERSHIP

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Abstract:

In the debate on value-creation in private equity, advocates commonly mention the long-term perspective as an advantage; thus the capital does not see the same quarterly pressure from shareholders as on the public markets. However, does this imply that private equity firms can invest more money in innovation, and hence create even more value in the future? We have analyzed this from 65 private equity investments in Sweden ranging from the year 2000 to 2015, using patents as a proxy for innovation. We found no evidence that private equity firms invest more in innovation than previous owners - rather the opposite seems to be prevalent. Private equity firms, however, are being slightly more successful in the outcome, hence quality, of their patent applications.

Keywords:

Private equity, Finance, Innovation, Patents, Value-creation

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THE NEVER-ENDING QUESTION, when talking about private equity firms, is obvious; do they create value for investors? More specifically, does the value they create incentives the drawbacks with deploying capital in a private equity fund, hence a lack of liquidity during the lifetime of the fund and limited visibility of the actual holdings? These dilemmas are broad and complex. However, a breakdown in the perspective of a private equity firm's mindset might provide guidance on how value-creating these firms actually are.

In the early days of private equity, Jensen (1989) wrote about the superiority of leveraged buyouts (LBO), commonly used among private equity firms. These types of private transactions, including a significant amount of debt, serve well to increase possibilities for corporate governance, monitoring by active owners, strong managerial incentives, and efficient capital structure. An LBO, they state, is far more effective than the public corporation with its dispersed shareholders and weak governance. That is, in part, since an LBO provides room for the owner to conduct long-term investments and sacrifice short-term profit, in order to create even more value in the long-run - which is consistent with the findings by, amongst others, Hall (1990) who proved that R&D expenditures increased after an LBO had taken place. But is this still accurate?

Clearly, the question is up for debate. Critics often claim that the long-term commitment of a private equity firm is closely connected with the lifetime of the fund. This would indeed be problematic. The fund's lifetime rarely exceeds eight years, and the risk that firms might use their LBO targets to make a quick IPO and thus maximize profit in the short-run is obvious, as stated by Shleifer and Summers (1988) and Kosman (2009). This is a way for private equity firms to make a more rapid internal rate of return on their investments, and simultaneously collect another round of management fees from raising a new fund with fresh inflow of capital.

The scope of private equity firms' strategies in making as high returns as possible is massive. There are numerous aspects to take into consideration, and naturally, they are very widespread with regard to different firms and regions in the world of private equity. The answer is not straight forward, neither is it ours to find. Rather, this thesis is about a component in their operational strategy of the firms; innovation in target companies.

Innovation in itself is obviously a wide term that can differ from the workforce, to research, to artificial intelligence. Zingales (2000) argued that one should go beyond the investments in physical assets made by a firm, and rather look at parameters like the development of research and development (R&D) expenses and patent activity. The R&D expenses of a company are indeed interesting, hence they tell whether the company got any headroom in their operations to invest in the future, which indirectly is the case with R&D activity. However, we will not examine R&D expenses closely in this thesis due to a few reasons. First and foremost, Jensen (1993) argues that the R&D expenses often prove to be ineffective, with many research activities being wasteful and yielding a low return on invested capital. This would make changes in R&D expenditures harder to interpret accurately, and thus the proxy for innovation lacks sufficient underlying power. Moreover, access to annual reports for private companies in Sweden is limited and based on the premise of paying for each and every report - hence not an option for this thesis.

Instead, we will examine the innovation in target companies using patents as a proxy for innovation. While there are certain limitations with this method as well - such as inventions being protected as trade secrets and thus not publicly available - patents are widely recognized and accepted as a procurator for innovation in private companies. Also, they are publicly available for both public and private companies, and thus we have been able to track development pre- and post a private equity firm has acquired the target company.

For the paper, we have examined all transactions where a Swedish private equity firm has acquired a Swedish target company from 2000 to 2015. This was, in total, 325 transactions. From these, we have manually analyzed their patent activity, where 65 proved to have applied for a patent either five years before, five years after, or within five years both before and after the transaction. More on the sample can be read in the separate section on this topic below. Throughout this thesis, we are referring to the "transaction" as simply being when a private equity firm is buying a company that was previously not owned by a private equity firm.

Our main finding is that we find no evidence of an increase in the number of patent applications post private equity investment, meaning that the degree of innovation is not

positively influenced by the entry of private equity ownership. Rather, we see the reversal direction in our sample, i.e. that the number of patent applications declines with private equity entering the playing field. As success in the field of innovation is not necessarily a numbers game, we also investigate how the ratio of granted patents/patent applications develops under private equity ownership, focusing on the efficiency and quality of the patent application, not just the activity itself. We find that the quality of the patent applications experiences a slight improvement post-transaction, possibly as a result of better allocated resources with a new owner.

As for the limitations of the thesis, we are aware of the relatively small number of observations. We do feel that Sweden is the region where we can add value to the already conducted research in the subject, and hence it was a clear choice for us to make. We could have included all the Nordic countries, however, this would have made it challenging to access the relevant databases for patents as they are not as reachable as in Sweden. This means that our number of observations is a limitation to be taking in consideration while reading this thesis. Moreover, we can not be completely sure if the transactions have actually been made in the form of an LBO. It is, however, a strong possibility that the transaction has included leverage and thus been an LBO, as this strategy is customary in the world of private equity.

I. Literature review

There are a number of related literature, with one being especially prominent. “Private Equity and Long-Run Investment: The Case of Innovation” by Josh Lerner, Morten Sorensen, and Per Strömberg (2011) does a very similar study on these questions in the US. The private equity landscape has gained true momentum in the previous decade and while Josh Lerner, Morten Sorensen, and Per Strömberg’s results are of great value, we have to be careful internalising their findings and take the time perspective into special consideration since the industry has experienced major changes in the past decade. However, while their methods and analysis are slightly different in terms of how they measure R&D expenses, they manage to prove a minor relationship between a private equity firm taking over as a new owner and the amount of investments in innovation associated with the new ownership. Furthermore, their main findings are that private equity owned firm patents are more cited, show no shifts in the fundamental nature of the

research, and become more concentrated in important areas of companies' innovative portfolios.

A number of other studies consider the impact of leverage - a somewhat prominent feature of private equity investments - on innovation. These studies typically examine publicly traded firms with varying levels of debt and reach somewhat ambiguous conclusions. A clear correlation between lower levels of R&D spending and greater leverage can be stated, as documented by Hall's (1992) examination of over 1,200 manufacturing firms and Himmelberg and Petersen's (1994) study of 170 small high-technology firms. However, whether causality is occurring or not is unclear. It is difficult to determine whether debt leads to R&D reductions or if struggling firms simply have more debt and less spending on innovation. Hao and Jaffe (1993) examine this question and conclude that more debt results in a lower amount of R&D spending only for the smallest firms. For larger firms, however, the causal relationship is ambiguous. Moreover, Atanassov, Nanda, and Seru (2007) examined the relationship between patenting activity and capital structure. Their main finding is that firms relying primarily on bank debt financing have fewer and less cited patents in comparison with firms relying on outside equity or bond financing. They interpret this finding as evidence that banks are less able to evaluate novel technologies and therefore discourage investment in innovation.

These earlier studies can admittedly be seen as somewhat outdated but are still of great importance when trying to understand this phenomenon. Firstly, the private equity industry has grown substantially since the 1980s and this growth not only generates a larger sample, but changes in the industry - such as more experienced and nuanced operational orientation from a private equity perspective and an increased competition between private equity groups. This questions the earlier studies' relevance and findings, given that we ideally would like to apply them in today's private equity landscape. Besides, the amount of transactions associated with technology-focused companies have increased enormously in recent years which has led to even greater differences compared to the earlier studies. Also interesting is to look beyond public-to-private transactions, since these transactions represent a tiny share of the total private equity transactions. Finally, the digitization of patent records (for instance via the Swedish Patent and

Registration Office's database) in recent decades has been crucial for our ability to measure and study the impact on innovation.

On another note, we isolate our analysis to focusing only on utility patents, i.e. not other measures such as design or reissue awards. According to Jaffe and Trajtenberg (2002), 99% of all awards are represented by utility patents and we can therefore conclude that this way of measuring innovation is fairly representable. Also, over the past three decades, a wide range of ways to measure patent quality have been adopted (Jaffe and Trajtenberg (2002); Lanjouw, Pakes, and Putnam (1998)). One of the most crucial metrics for this purpose is to which degree the patent is cited as citations are immensely important in patent filings since they can be seen as "property markers" which further validates the filing. Generally, a more frequently cited patent is typically equal to a more valuable and important patent compared to a patent with less citations.

II. The Sample

A. Identifying Private Equity Transactions

To identify private equity investments in Sweden between 2000 and 2015, we dissect the Securities Data Companies (SDC) Platinum database and International Mergers (IMA). SDC Platinum is a Thomson Reuters' software application that is the industry standard for information on new issues, M&A, syndicated loans, private equity transactions, and more. SDC Platinum provides us with a robust database spotting every private equity transaction made in Sweden during these years and includes vital key ratios, ownerstakes, and firm characteristics.

Firstly, we assume that all private equity transactions consist of interest-bearing payment, i.e. the use of leverage and hence that all transactions are to be considered as LBO's. Secondly, the database automatically duplicates a few transactions as the way of buying the companies sometimes varies and could in line with that be split into different parts (even if it is the same transaction), hence we delete those "double-transactions" from the sample as it does not impact the innovation activity and thus should not be included as a separate variable in the dataset.

Sourced from the SDC database, we also divide our sample into sub-categories, such as industry, to be able to deeper analyse the patterns of patent activity. That allows us to see if any sectors are being more or less affected by the private equity investment. As an interesting side effect, this also reflects the private equity firm's industry focus on a more general level as we, with help from the database, have listed the percentage share of the sample firms that are associated with a certain industry. However, this is highly weighted towards innovation (patent activity) since the sample consists of nothing but companies associated with patent activity. Moreover, the results from the sample is, which can be found in the 'Summary Statistics' section, also presented for each year, making it easy to compare.

B. Capturing Patent Data

As previously mentioned, we use patents as a proxy for innovation. To collect the patent data for our sample, we use the Swedish Patent and Registration Office's database, a publicly available information source which contains all the applied-for and confirmed patents in Sweden. As the database highlights both the applied-for patents and the granted patents, we can add another datapoint called '# of patents applied for which was not granted' since we have the residual of the applied-for patents and the actual confirmed patents.

To further delimitate the data and make it comparable, we restrict our sample to firms with at least one successful patent application from five years before the transaction to five years after the transaction. In total, we identify 65 transactions where the target company is associated with patent activity logged within the period from five years before the transaction to five years after the transaction. Indeed, our initial sample consisting of all companies associated with a LBO transaction between the year 2000 to 2015 did contain significantly more data points, but as patent activity is crucial for the analysis, we isolate our sample to those private equity transactions where patent activity is registered.

As most companies associated with a private equity investment do not entail patent activity, we have to subtract those from our initial sample which results in a relatively

small number of companies. However, as we examine this activity over 15 years, we still find it significant. For instance, companies within the retail sector, or the media sector, do not, in general, hold a great amount of patents (if any), which we also found evidence for and are thus not of interest when analyzing innovation with patents as our proxy.

Table I

Summary Statistics

The full sample included in our analysis consists of 532 patent applications from a total of 65 companies that were acquired by a private equity firm between 2000 and 2015. These 65 companies were derived from a total of 325 private equity investments in the period, where the 65 were the ones that involved any kind of patent activity during the range of five years before the transaction to five years after the transaction. The industry classification used in Panel B is from SDC Database, as are the data in general.

Panel A: Transaction years for private equity deals involving companies with patents in our sample, and application and grant years for those patents

		Patents	
Year	PE Transactions	Applications	Grants
2000	4	0	0
2001	8	16	1
2002	0	11	4
2003	1	7	7
2004	7	6	17
2005	4	20	9
2006	4	11	5
2007	5	15	9
2008	3	9	9
2009	4	12	9
2010	4	11	5
2011	7	28	10
2012	4	13	8
2013	3	8	11
2014	2	10	3
2015	5	11	9
Total	**65**	**188**	**116**

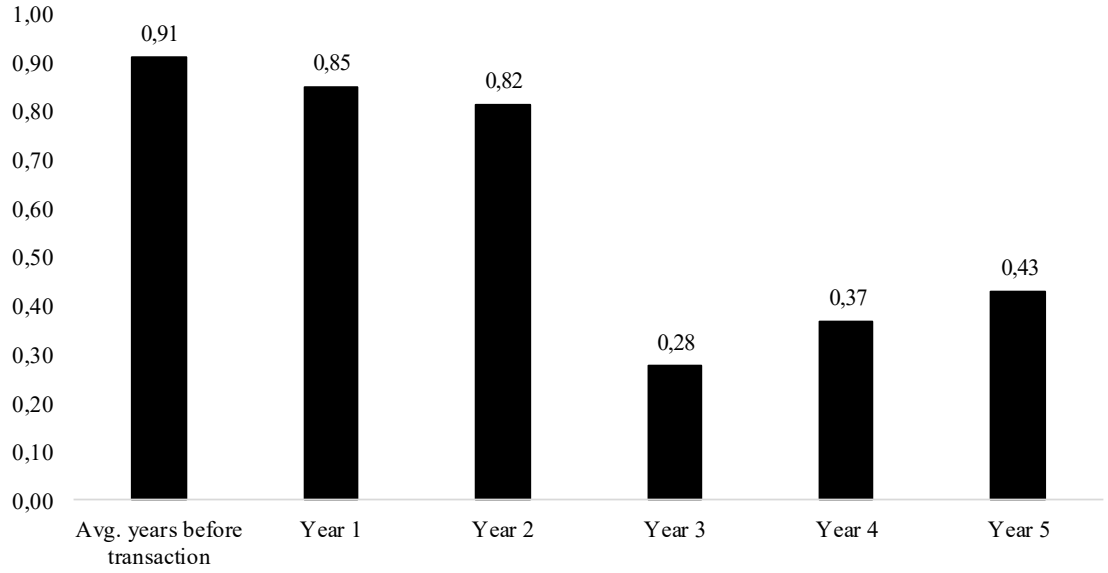
Panel B: Industry distribution of private equity investments with patent activity in [-5, +5] years around transaction, and their associated patents: Top industries in sample

Industry	% of sample firms	% patent applications	
		Pre transaction	*Post transaction*
Business services	13,8%	3,7%	6,8%
Machinery	13,8%	8,6%	16,0%
Measuring, Medical, Photo Equipment	9,2%	7,4%	6,3%
Wholesale Trade-Durable Goods	7,7%	5,5%	3,9%
Electronic and Electrical Equipment	6,2%	0,9%	7,3%
Prepackaged Software	6,2%	1,5%	1,0%
Paper and Allied Products	4,6%	7,4%	5,8%
Drugs + Chemicals	4,6%	40,5%	16,0%
Metal and Metal Products	4,6%	0,6%	4,4%
Construction Firms	4,6%	0,3%	1,0%
Others	24,6%	23,6%	31,6%
Total	100,0%	100,0%	100,0%

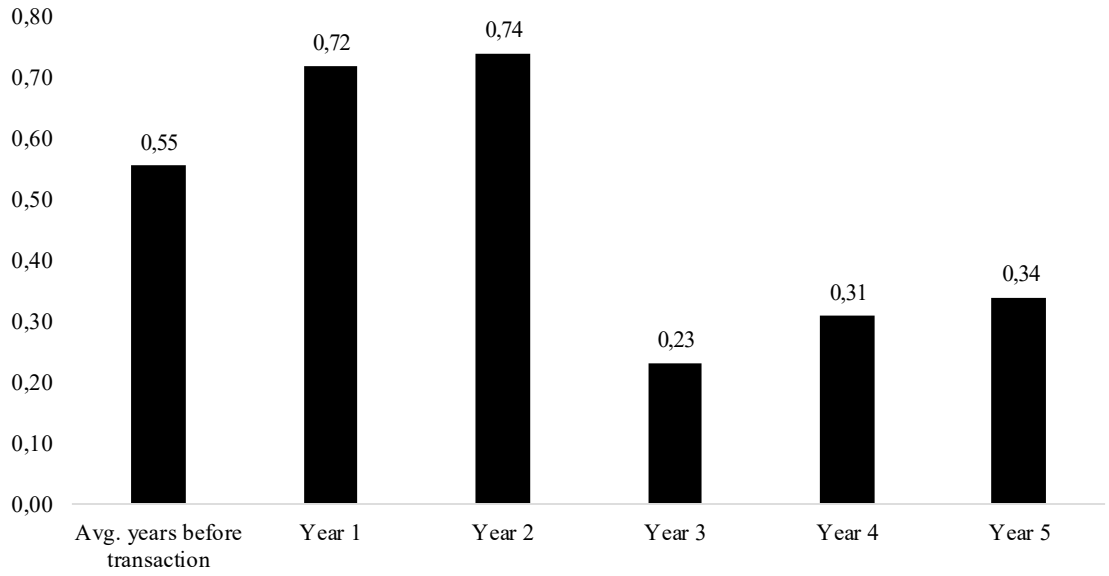
Panel C: Lag between private equity investment and patent application

	Number of Applications
One to five years prior	326
Average per year prior	*65,2*
Year of investment + one year after	83
Two years after	53
Three years after	18
Four years after	24
Five years after	28

Panel D: Average patent applications in the window period surrounding the transaction



Panel E: Average patent applications in the window period surrounding the transaction, excluding the company "Perstorp AB"



Panel A illustrates the number of private equity investments with patent active companies that occurred in the respective year of the study's scope. It tells how many patents that were applied for, and granted, in the respective years. One can note that the patent applications saw a slight increase in the middle of the period - except for 2008, i.e. the financial crisis - which is consistent with the findings of Sorensen et al (2011). A more general conclusion throughout all years is that ca. 62% of all patent applications are granted, however, an important aspect to take into consideration is that patents granted six or more years after the transaction is not included in the column of patents granted. Hence, the actual "granted-ratio" is higher than what's shown in the panel. More specifically, when extrapolating as described in "Exhibit II", the ratio is 0.92 before transaction and 0.95 after transaction.

Panel B shows the composition of the top ten industries and their associated patents, where all patents are assigned an industry class as defined by the SDC Database. Most conspicuous is that business services and prepackaged software are underrepresented in patent activity compared to their relative size in the sample. On the flip side, drugs and chemicals are massively overrepresented, with the pre-column being remarkable. This can be derived from an outlier in the sample, the company Perstorp which was acquired by IK in 2000, who made a very large number of patent applications in the late 1990s.

Panel C is illustrating the lag between a private equity transaction and the target's patent activity. We have not split up the respective years before the transaction, as this was irrelevant from our point of view, and not statistically significant on a single-year basis. Instead, to make it comparable in the panel, we calculated an average on the years before transaction for illustrative purposes. In line with the findings of Sorensen et al (2011), the patent applications observed are disproportionately high immediately after the transaction compared to 3-5 years after the transaction.

Panel D is a graph containing the average number of patent applications for all firms in the different stages surrounding the transaction. This is included to get some knowledge of the preliminary picture of the data and shows that the number of patent applications does not seem to have any particular correlation with the acquisition of private equity firms, or a slightly negative one - more on this will follow in the section of analysis.

Panel E is the same as Panel D, but excluding one (1) of the 65 companies originally included in our sample. That is the company Perstorp AB, which was acquired by Industri Kapital AB (IK Investment Partners) in 2000. This company has a major impact on our regressions, and thesis in general, because of its massive amount of patent applications - particularly before the private equity transaction. This should be taken into consideration throughout reading this paper, and the graph in Panel E is to illustrate the difference from when including it in the sample (Panel D).

III. Method

As for the method of this thesis, we focus on patent applications from a number of different perspectives. This in order to create a more nuanced approach to whether private equity firms are positive or negative for innovation in their portfolio companies. Our main regression focuses on the number of patent applications, and whether this number increases as the private equity firm acquires the company. We use a window of five years before and five years after the actual transaction, to evaluate if any substantial differences can be seen. To provide more nuance on this, we also spread out the patent applications on a year-by-year basis - and hence not in clusters of five - in exhibit III. This creates a more dynamic perspective to the quantity of patent applications before and after the private equity transaction. Furthermore, we see it from a qualitative perspective, where the patent applications are compared to the patents confirmed by the Swedish Patent and Registrations' Office, and if this ratio is different after than before the transaction. Lastly, we do a deep-dive in some particular sector of interest that is substantial to our tests - the machinery sector and healthcare sector - in order to give more light to firms with industry specific characteristics and create a case study on a part of our sample.

The investigated patterns are indicative of if private equity firms actually care for long-term value creation, using innovation as a proxy for that and patents as a proxy for the latter. If we cannot see any correlation between the quantity or quality of the patent activity, or negative correlation, the critics of private equity firms' responsibility might seem to be correct. On the other hand - if we do see that the quality and/or quantity increase post-transaction, the views of Jensen (1989, 1993) and Sorensen et al (2011) likely are correct also in a Swedish context.

Compared to previous research in the area of innovation in private equity, this thesis got a slightly different extension. We have purely based our research on the Swedish market, while previous papers have used a more worldwide and/or US-based approach. Also, we have extended the cut-off point regarding time to cover a more modern world, as we draw the deadline for included private equity transactions in 2015. This is important since the world of private equity is evolving rapidly, and the general methods of value-creating have seen significant shifts; from pure financial engineering to actually improving a target's operational performance and taking a more active ownership approach.

Exhibit I. Output Ordinary Least Squares regression regarding patent applications before and after the PE transaction.

Regression Statistics	
Multiple R	0,077032423
R Square	0,005933994
Adjusted R Square	-0,001832146
Standard Error	12,04033685
Observations	130

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	110,7692308	110,7692308	0,764085336	0,383690133
Residual	128	18556,12308	144,9697115		
Total	129	18666,89231			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	5,015384615	1,493419986	3,358321613	0,001033264	2,060398023	7,970371208	2,060398023	7,970371208
X Variable 1	-1,846153846	2,112014798	-0,874119749	0,383690133	-6,025135962	2,33282827	-6,025135962	2,33282827

To explain the relationship between patent applications filed for 5 to 0 years before the private equity transaction with 0 to 5 years after the private equity transaction, we use an ordinary least square regression (OLS). The OLS is a powerful technique for modeling continuous data, particularly when it is used in conjunction with dummy variables as in our case.

The full sample consists of 65 firms that got acquired by a private equity firm between the years 2000 and 2015. Firms are only included in the sample if patents were applied for between five years before and five years after the private equity investment. The unit of observation is the number of patent applications that a private equity-backed firm has encountered each year during the period from five years before the transaction to five years after the transaction.

To explain this regression, we use a binary variable x (0 or 1) where '0' represents the five years before the private equity transactions and '1' represents the five years after the private equity transaction. As the multiple R coefficient shows, the correlation between the number of patent applications in the span of 0 to 5 years before the private equity transaction and the span of 0 to 5 years after the private equity transaction is immensely low. Consequently, the R squared, which also can be found in the Goodness of Fit, thus gives us no explanatory evidence of the hypothecated correlation. It states that only ca. 0.6% of the variation of y-values around the mean is explained by our binary x-values, i.e. ca. 0.6% of the values fit the model. However, as we are using more than one x variable, we focus our analysis on the 'adjusted R square' as this output adjusts for the number of terms used in our model. The adjusted R square decreases when a predictor improves the model by less than expected by chance. That is, our negative adjusted R square appears when the residual sum of squares approaches the total sum of squares which means that the explanation towards response is very low or negligible. In other words, a negative adjusted R square means insignificance of explanatory variables, which can be seen as a proof of contrast to our hypothesis. Our results could indeed be improved with the increase in sample size or avoiding correlated independent variables.

We also see a significant variation in our sample, mined from our standard error. This is primarily due to a few numbers of relatively mega active companies filing for patents, for instance, Perstorp AB. Furthermore, the hypothesis that the number of patent applications increases with private equity backing can not be found significant since the t-statistic is

negative. The fact is that the negative t-statistic rather proves that there is a reversal directionality in contrast to the hypothesis, i.e. the entry of private equity ownership in the sample has a negative impact on the number of patent applications. However, although the negative t-value shows a reversal directionality, compared to the hypothesis, in the number of patent applications, it has no impact on the significance of the difference between groups of data.

One reason why the total number of patents decreases in the sample post-transaction could be that the private equity firm sets a new strategy for profitability. Pre-transaction, the companies' main focus has historically been centered around its core operations but consequently, as a more financially focused owner (the private equity firm) enters the board room, a higher extent of financial focus will follow and hence impact the financial - and operational - outcome. That is, cost-cutting in business areas that are less crucial for daily profitability and streamlining certain operations throughout the organisation are essential and well-proven private equity strategies for increasing short-term profitability. The cost-cutting strategy does, undoubtedly, have direct consequences on business areas that does not yield any high returns short-term, namely R&D expenses and other expenses associated with innovation, which could be one factor for why the number of patent applications decreases in the sample post-transaction compared to pre-transaction.

Another reason could be found in a more operational oriented strategy. That is, private equity firms, possibly as a result of the cost-cutting strategy, streamline as many business functions as possible in as short a timeframe as possible to make their portfolio companies more efficient and thus more profitable. Noteworthy, this strategy does not necessarily have a negative impact on the companies' long-term value, as a potential outcome is that the company becomes more efficient with less allocated resources which, undoubtedly, is positive for the long-term value of a company. However, even if the companies, as a result of the streamline strategy, are becoming more efficient in their patent processes, the net outcome of patents granted decreases, as can be seen in the drop in patent applications post-transaction.

The cost-cutting strategy has been highly criticised in the history of private equity as it, among other reasons, has caused a significant number of people their unemployment and transformed several beloved and highly esteemed companies to machine-like companies without souls. However, the negative reputation that this strategy has envenomed the

private equity industry is not necessarily fair as this strategy, at its core, is highly efficient in making a company more thoughtful in regards to their spendings, thus increasing profitability which, at the end of the day, is the whole purpose of running a business. Consequently, as this is such a fundamental private equity strategy for creating value in their portfolio companies, the aspect of cost-cutting is likely one of the key factors for why the number of patent applications decreases post-transaction - especially when combining with streamlining the business and making it more effective with the resources remaining in the firm.

Exhibit II. Output Ordinary Least Squares regression regarding the quality of patent applications, expressed as ratio confirmed/applications before and after the transaction.

Regression Statistics	
Multiple R	0,098424462
R Square	0,009687375
Adjusted R Square	-0,015070441
Standard Error	0,192182282
Observations	42

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0,014451751	0,014451751	0,391285514	0,535177339
Residual	40	1,477361186	0,03693403		
Total	41	1,491812937			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0,909375	0,041937612	21,68399564	1,00349E-23	0,824615924	0,994134076	0,824615924	0,994134076
X Variable 1	0,037099289	0,05930874	0,625528188	0,535177339	-0,082768146	0,156966723	-0,082768146	0,156966723

Here we compare the number of patents applied for with the number of patents actually granted by the Swedish Patent and Registration Office, assigning each company a ratio where the number of granted patents is divided by the number of patent applications. Also, this regression is binary, with the explanatory variable determining whether it is before or after the transaction, and thus if the company has increased or decreased the quality of their patent applications when a private equity firm enters as a new owner.

When doing this regression we had to extrapolate our sample; we only used data for the firms where a transaction happened in or before 2010, as patent applications from targets after that might still be pending. That is, if a company became private equity-owned in 2013 and sent a patent application in 2017, the outcome might very well still be pending and thus we could not include these companies in the sample at all. Moreover, we removed all firms that had only made patent applications either before or after the transaction - that is, only on one side of the transaction. In order to make the comparison, the company naturally must have had patent activity both before and after the transaction. These extrapolating choices resulted in a sample of 21 companies.

In comparison with the other regressions made in this thesis, this one focuses on the actual quality of the patent activity, hence this one should be considered the best add-on to the results shown in Exhibit I. That is, this ratio shows how efficient and successful companies are in their patent activity, not just how active they are. As the number of granted patents cannot exceed the number of patent applications, the ratios lie between 0 and 1, where 0 reflects the lowest possible quality and 1 reflects the highest possible quality of the patent applications. Worth highlighting is that this, obviously, does not tell us something about the quantitative activity itself, only the quality. Hence, it's not a value-adding metric if not analysed together with the data presented in Exhibit I.

As seen in the Goodness of Fit, the numbers are nearly corresponding to those seen in Exhibit I, meaning that our values hardly fit the model. One parameter, however, that differs from our previous regression is the standard error, which is significantly lower when comparing the ratio '# of granted patents'/'# of patent applications'. This would not be surprising since we are comparing ratios and not absolute numbers, making the input much more normally distributed, for instance as presented in Exhibit I. That being said, we should not rely too much on the standard error in this regression as it is naturally lower than in comparable regressions.

In contrast to the results shown in Exhibit I, we find a significant t-statistic when comparing the ratio '# of granted patents'/'# of patent applications' five years before the transaction and five years after the transaction. We find that the average quality of the patent applications experience a slight improvement after the transaction (0.91 vs. 0.95), possibly as a result of better-allocated resources with a new owner (and perhaps also a new management team). On a general level, it could thus be stated that the quality actually improves after private equity entry.

When conducting detailed due diligence regarding the quality of patents, one quickly stumbles across the papers of Jaffe and Trajtenberg (2002) and Lanjouw, Pakes, and Putnam (1998). These provide a solid explanation on how the quality should be judged, and mainly refers to the number of citations that a specific patent has. In our thesis, however, we have not made an effort to dig this out, as the market for citations in Sweden is relatively scarce when compared to, for instance, the US. Instead, the quality is being judged on how successful a company's patent application has been when being in front of the Swedish Patent and Registration Office.

There are a number of potential reasons for why the general quality of the patent applications increases post-transaction. According to Bain & Company's annual 'Global Private Equity Report 2020' (Bain 2020), one could be that private equity companies have become more sophisticated in the way they create value in their portfolio companies. To highlight a few examples, the old school value-creation strategies in private equity companies have historically included financial engineering, consolidating business areas to create synergies, extensive cost-cutting throughout the organisation to increase margins, etc. Since the total amount of capital on the market has increased significantly over the years, private equity companies have had to widen their offerings to attract potential investment prospects. Also, as these traditional strategies have been enhanced by not only a large number of individual private equity firms but the industry as a whole, more nuanced and sophisticated methods have been forced to develop.

Innovation and R&D are certainly major factors for long-term growth, and companies with a strong R&D position have therefore been premiered by investors. Consequently, private equity firms, which do not necessarily have had any previous knowledge or experience with regards to innovation and more precisely patents, have over the years learned the mechanics of the patent system which, over time, has generated a lot of

clustered knowledge in-house. Sharing that knowledge to their portfolio companies, that has made private equity firms' portfolio companies way more efficient in their innovation processes, and the knowledge that private equity firms have collected over the years has been a major support and guidance in what to focus on - and what to not focus on - in the innovation process.

EXHIBIT III. Output Ordinary Least Squares regression regarding patent applications by Private Equity-owned firms five years before the transaction to PE-ownership and five years after on a year-by-year basis.

Regression Statistics	
Multiple R	0,249755343
R Square	0,062377732
Adjusted R Square	0,057336752
Standard Error	9,444463333
Observations	188

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1103,746088	1103,746088	12,3741281	0,000547084
Residual	186	16590,8071	89,19788765		
Total	187	17694,55319			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	7,086956522	1,392510149	5,089339226	8,7501E-07	4,339812342	9,834100702	4,339812342	9,834100702
X Variable 1	-5,636252296	1,602260482	-3,517687891	0,000547084	-8,797191958	-2,47531263	-8,797191958	-2,475312635

The original sample used for this regression consists of 65 firms that got acquired by a private equity firm between the years 2000 and 2015. After extrapolating, firms are only included in this regression if patents were applied for five years before and five years after the private equity investment. In this regression, we deleted the firm observations that accumulated zero [0] in total in year 1-5 before or after the private equity transaction. Then, we pointed out all the observations after the transaction year-by-year for the different firms, until the respective company stopped applying for patents. That is, we narrowed the window to -5,+x (1-5) depending on when the company stopped applying for patents, and thus our window now became more dynamic than in Exhibit I, where it is strictly -5,+5. As a result of spreading it out year by year, naturally, the number of observations increased and the result can be seen above. This regression is not balanced, as the "patent window" can be -5 to +2 compared to -5 to +5 in Exhibit II.

To further explain the mechanics behind this regression, we use a binary variable x (0 or 1) where '0' represents the five years before the private equity transactions and '1' represents the five years after the private equity transaction. Also, similarly to Exhibit I, the R squared, which can be found in the Goodness of Fit, states that ca. 6% of the variation of y-values around the mean is explained by our binary x-values, i.e. ca. 6% of the values fit the model.

The regression shows a coefficient for the dummy x that is equivalent to ca. -5.6. That is, on average, in the year post private equity transaction the number of patent applications is ca. 5.6 less than before the private equity investment. Looking at Panel C and Panel D in 'Summary Statistics', we see a relatively massive decline in the number of patent applications post private equity entry in our sample. One could argue that this is a direct consequence of that private equity companies have built clustered knowledge banks in-house which does not only provide portfolio companies with guidance in regards to be more efficient in their actual patent applications but also which patent areas that they should stay away from. Followingly, one reason why the number of total generated patent applications have decreased in private equity-backed companies is likely that the innovation efforts are better allocated.

Another reason why the number of patent applications has decreased post private equity transactions can be found in KPMG's 'Nordic Private Equity Assets 2019' report (KPMG, 2019). In short, the report examines the 35 leading private equity firms in

Sweden and their investments between 2001 and 2019. Of the 207 companies which have been divested between the years 2016 and 2019, one key takeaway is that the average exit period counts to 6.1 years, i.e. how long it, on average, takes from investment to divestment. This takeaway, however, has to be taken with a pinch of salt since our timeframe (the years 2000 to 2015) is not necessarily applicable to this as the private equity industry, which we have elaborated on earlier in this thesis, has undergone some major changes in the recent decade.

The paradox of the lifetime value (LTV) of a company vs. the LTV of an investment has made its mark on the never-ending debate whether private equity firms are actually adding long-term value to their portfolio companies or not. That is, private equity firms' time horizons are shorter than their portfolio companies', and hence the set of incentives differs. One could argue, however, that private equity firms add short-term value in order to drive long-term growth and stability, but the incentives are undoubtedly different which impacts the performance of the companies, both short-term and long-term. In addition to our results, the KPMG's report indicates that private equity firms sacrifice long-term value in order to maximise short-term (on average 6.1 years) profit. Given that innovation is critical for economic growth and long-term stability, this pattern that private equity-backed companies show is clearly harmful.

In a survey consisting of 400 public company executives, Graham, Harvey, and Rajgopal (2005) found that 78% admit to sacrificing long-term value to short-term earnings. In line with that finding, Bushee (1998) finds that firms with a high fraction of ownership by short-term institutional investors are more likely to reduce R&D expenditures in order to counteract an earnings decline. Looking from another perspective, Atanassov, Nanda, and Seru (2007) report that firms relying on public equity and bond financing, as opposed to bank debt financing, have a larger number of patents and note that these patents are more cited. Furthermore, Ferreira, Manso, and Silva (2010) develop a theory of differences in incentives to innovate in private and public companies that further stresses this phenomenon.

Exhibit IV. Output Ordinary Least Squares regression regarding patent applications before and after the PE transaction in the machinery sector.

Regression Statistics	
Multiple R	0,08978817
R Square	0,008061916
Adjusted R Square	-0,053934215
Standard Error	3,268111925
Observations	18

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1,388888889	1,388888889	0,130039012	0,723108269
Residual	16	170,8888889	10,68055556		
Total	17	172,2777778			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	3,111111111	1,089370642	2,855879342	0,011440903	0,801748515	5,420473707	0,801748515	5,420473707
X Variable 1	0,555555556	1,540602736	0,360609223	0,723108269	-2,710376348	3,82148746	-2,710376348	3,82148746

The sample consists of 9 firms operating in the machinery sector that got acquired by a private equity firm between the years 2000 and 2015. Firms are, as in previous regressions, only included in the sample if patents were applied for between five years before and five years after the private equity investment. The unit of observation is, similarly to Exhibit I, the number of patent applications that private equity-backed firms have encountered each year during the period from five years before the transaction to five years after the transaction. As shown in Panel B in 'Summary Statistics', companies associated with the machinery sector stand for ca. 14% of the sample firms making it an important contributor to our results. Hence, it would be interesting to see if we could find any differences compared to the results we found in the full sample and thus if any industry-specific characteristics occur.

In this regression, we use a dummy variable x (0 or 1) where '0' represents the five years before the private equity transactions and '1' represents the five years after the private equity transaction. As both the Multiple R coefficient and R Square shows, the correlation between the number of patent applications in the machinery sector in the span of 0 to 5 years before the private equity transaction and the span of 0 to 5 years post private equity transaction is indeed low. Similarly to Exhibit I (with the full sample included), this gives us no explanatory evidence of the hypothecated correlation. Also, we see a significantly lower standard error in comparison with the results in Exhibit I, likely as a consequence of the smaller sample size.

Looking at the coefficient for the dummy x, we find that in the year post private equity transaction, the number of patent applications are, on average, ca 0.55 more than before the private equity transaction. That is, we get different results isolating our analysis to the companies operating in the machinery industry compared to our full sample which had an equivalent coefficient at ca. -1.85, meaning that the number of patent applications, on average, decreased post private equity transaction. In other words, from an innovation perspective, companies operating in the machinery sector that are acquired by private equity firms are better off than the average company in the full sample. However, this sample is not necessarily representable as it only consists of 9 firms, making the deep-dive more of a spot check than a sample for significance.

On another note, in panel C, we see a massive overweight in the number of patent applications for the drugs & chemicals sector, primarily pre-transaction, in comparison

with other examined sectors. Indeed, the data is relative as we compare the percentage share compared to other industries, but if we isolate our analysis to comparing the patent activity only within this particular industry pre-transaction and post-transaction, we see a massive decline. From representing 40.5% of the patent applications in the sample pre-transaction to only 16.0% of the patent applications in the sample post-transaction, this could rely on two main explanations. Firstly, the massive decline could be an instant result of a less amount of resources being allocated to the R&D function within the particular company and industry as the private equity firm enters the game, i.e. private equity failure in creating long-term value in the company. Secondly, as we elaborate on the percentage share of patent applications compared to other industries, another reason could be that other industries are keeping up or that the drugs & chemicals industry was peculiarly active in the years pre-transaction. However, one must also note that the company "Perstorp AB" has a significant impact on the sample, and even more so on the cluster of drugs & chemicals-companies - and thus they naturally have a large impact on the extensive relative decline in patent applications.

Another set of literature examines how leveraged buyouts affect innovation at a more general level. Focusing on private equity buyouts in firms within the manufacturing sector during the 1980s, Hall (1990) looks at 76 public-to-private transactions, i.e. transactions in which a publicly-traded firm is purchased and taken private. Hall's main conclusion is that the impact of these transactions on cumulative innovation is modest. Noteworthy is that even if these firms represent 4% of manufacturing employment in 1982, they account for only 1% of the R&D spending. Furthermore, Lichtenberg and Siegel (1990) dissect 43 LBOs during the 1980s that participated in the Bureau of the Census's survey about research activities pre-transaction and post-transaction. One main finding is that the firms associated with these 43 LBO transactions increase their research spending post-LBO, interestingly both on an absolute basis and relative to their peers.

V. Conclusion

This paper examines changes around the time of investments by private equity groups in firms' long-run investments, focusing on innovative activities with patents as our proxy for innovation. We examine patents from 65 different companies having experienced an

acquisition by a private equity firm and set the timeline of activity to five years before the transaction to five years after the transaction. We find no evidence of an increase in the number of patent applications after the private equity investment. In fact, we see the reversal trend compared to the hypothesis in these 65 companies, meaning that the number of patent applications decline with private equity involvement.

Another major conclusion is that the quality of innovation improved as a possible result of the transaction. We find that the average quality of the patent applications experience a slight improvement after the transaction (0.91 before compared to 0.95 after), possibly as a result of better allocated resources with a new - very financially oriented - owner. One could argue that this makes total sense - the quality of the patent applications should indeed be improved when decreasing the number of applications heavily.

As mentioned in the introduction, Jensen (1993) argues that the R&D expenses often prove to be ineffective, with many research activities being wasteful and yielding a low return on invested capital. Private equity firms have, naturally, entailed this knowledge into their investment models in order to maximise their portfolio companies' profitability. Jensen's findings can thus act as guidance for private equity firms in how to allocate resources as efficiently as possible; invest less in R&D and hence generate higher returns on the remaining capital actually invested in innovation. The main takeaway from this being that as the essence of the R&D department is being stripped by private equity firms, the outcome per invested R&D unit increases and hence the quality of the patent applications improves.

Nonetheless, this potential causality leads to an important and somewhat unfavourable conclusion; the net outcome of innovation, seen from a patent perspective, is negatively impacted when a private equity firm enters, as the increase in patent quality is offset by the substantial decrease in quantity.

Appendix: Transactions involving patent activity

Date	Target Name	Acquiror Name
04-10-00	Perstorp AB	Industri Kapital AB
10-05-00	Newmad Technologies AB	Bure Equity AB
10-09-00	Q-Labs AB	Ratos AB
12-13-00	AppGate AB	Bure Equity AB
02-12-01	Appelberg Publishing Group AB	Bure Equity AB
02-22-01	Framfab ITC,Integration	Nordic Capital Advisory AB
03-30-01	Callenberg AB(Expanda AB)	Segulah Advisor AB
04-26-01	Convenio(Citat AB)	Bure Equity AB
05-10-01	Framfab Technology AB(Framfab)	Bure Equity AB
06-13-01	Electrolux-Leisure Appliances	EQT Northern Europe Private
07-03-01	Xdin AB	Bure Equity AB
09-28-01	Duni AB	EQT Northern Europe Private
10-07-03	Cefar Medical AB	Accent Equity Partners AB
01-14-04	Norden Pac International AB	Nordstjernan AB
01-26-04	Thermia AB	Procuritas Capital Investors
01-27-04	Gadelius Europe AB	Ratos AB
04-26-04	Dynapac AB	Altor 2003 Fund
05-26-04	Wernersson Ost AB	Accent Equity Partners AB
08-17-04	HMS Industrial Networks AB	Segulah II LP
12-22-04	Munksjo AB	EQT III Ltd
03-08-05	Atos Medical AB	Nordic Capital Advisory AB
04-28-05	Envac Centralsug AB	Stena Adactum AB
06-30-05	PAX Electro Products AB	Litorina Kapital 1998 KB
12-13-05	Tolerans AB	Litorina Kapital 1998 KB
06-21-06	ELFA AB	Industri Kapital AB
07-06-06	Piab AB	Altor Fund II AB
12-13-06	Isaberg Rapid AB	Segulah Advisor AB
12-19-06	Etac Sverige AB	Nordstjernan AB
03-29-07	Corroventa Avfuktning AB	Volati AB
06-15-07	Q-MATIC Sweden AB	Altor Fund II AB
06-29-07	EuroMaint AB	Ratos AB
12-03-07	Gunnebo AB	Stena Adactum AB
12-18-07	Mont Blanc Industri AB	Accent Equity Partners AB
03-31-08	Bindomatic AB	Valedo Partners Fund I AB
04-15-08	Amcor Ltd- Flexible Packaging	Accent Equity 2008
05-29-08	Akers AB	Altor Fund II AB

(Cont'd on next page)

05-11-09	Carmel Pharma AB	Priveq Investment AB
09-17-09	Transmode Systems AB	Pod Venture Partners AB
11-06-09	Bergteamet AB	Accent Equity 2008
12-17-09	Scanacon AB	Capilon AB
02-04-10	Team Ortopedteknik Scandinavia	Volati AB
06-02-10	HL Display AB	Ratos AB
07-30-10	Mediplast AB	Priveq Investment AB
12-20-10	Thule Group AB	Nordic Capital Fund VII
06-07-11	CTEK Sweden AB	Altor Fund III
07-08-11	Silva Sweden AB	Karnell
07-12-11	Corvara AB	Accent Equity 2008
09-20-11	Kemetyl AB	Segulah III LP
10-25-11	Oasmia Pharmaceutical AB	Nexttobe AB
11-11-11	Sveba-Dahlen Group AB	Litorina Capital Advisors AB
12-02-11	Etac AB	Nordstjernan AB
01-10-12	Hansa Medical AB	Nexttobe AB
02-16-12	Fiskarhedenvillan AB	Litorina IV
03-06-12	Nordic Water Products AB	Alder AB
03-27-12	Nordic Tankers-Chemical Tanker	Triton Fund III
05-02-13	Axiomatics AB	Monterro Holdings AB
07-02-13	Moberg Pharma AB	Bure Equity AB
08-17-13	Hissgruppen Sverige AB	Accent Equity 2012
03-01-14	STARK Corporate Communication	More Ventures Nordic AB
10-03-14	San Sac AB	Accent Equity 2012
03-16-15	Troax Group AB	Investment AB Latour
06-23-15	Spotify AB	Northzone Ventures AB
10-15-15	Nordic Traction AB	Accent Equity 2012
11-17-15	PMC Group AB	Nordstjernan AB
12-02-15	Nordic Modular Group AB	Nalka Invest AB

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